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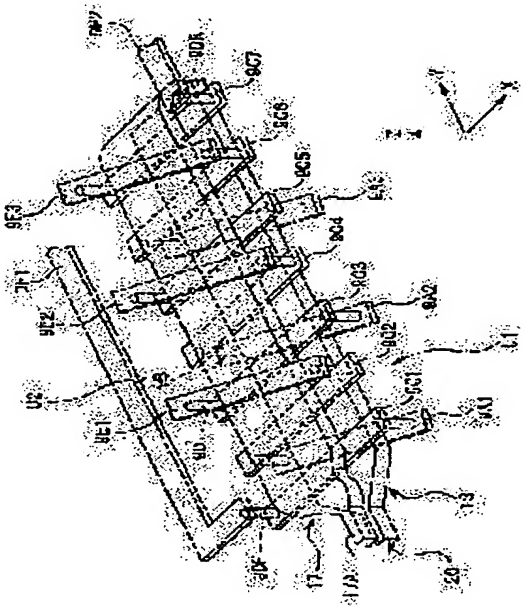
(54) MAGNETIC HEAD AND ITS MANUFACTURING METHOD

(57)Abstract:
PROBLEM TO BE SOLVED: To provide a magnetic head and its manufacturing method, capable of shortening manufacturing time and improving manufacturing yield while miniaturizing a coil.
SOLUTION: A thin-film coil 9 is constructed to form a continuous body where a first winding unit U1 winding clockwise around a lower magnetic pole 13, and a second winding unit U2 winding counterclockwise around an upper magnetic pole 17 are alternately connected. When the number of coil winding times is increased, a space between coil parts 9C becomes dense, while coil parts 9A or 9E are sufficiently separated from each other. The formation of the coil part 9C requires high forming accuracy. However, since the formations of the coil parts 9A and 9E do not require forming accuracy as high as that during the formation of the coil part 9C, the ratio of parts needing high forming accuracy in the thin-film coil 9 is reduced.



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CLAIMS

[Claim(s)]
[Claim 1] The two magnetic substance which has two magnetic poles arranged so that a record medium may be faced while countering mutually through a gap, and extends with this field in the direction to leave from the record-medium opposed face which faces the aforementioned record medium and which was connected magnetically. The coil which extends along the extension direction of the two aforementioned magnetic substance including the 2nd winding unit wound around a direction and opposite direction predetermined [aforementioned] centering on the magnetic substance of another side of the 1st winding unit and aforementioned two magnetic substance wound in the predetermined direction centering on one magnetic substance of the two aforementioned magnetic substance. The insulator with which the aforementioned coil is insulated from the two aforementioned magnetic substance. It is the magnetic head equipped with the above, and the aforementioned coil is characterized by making the continuum which comes to connect the winding unit of the above 1st, and the winding unit of the above 2nd by turns.
[Claim 2] The aforementioned gap, the two aforementioned magnetic substance, the aforementioned coil, and the aforementioned insulator at least are the magnetic head according to claim 1 characterized by being what consists of a thin film.
[Claim 3] Two magnetic layers which have two magnetic poles arranged so that a record medium may be faced while countering mutually through a gap layer, and extend with this field in the direction to leave from the record-medium opposed face which faces the aforementioned record medium and which were connected magnetically. The thin film coil which extends along the extension direction of the two aforementioned magnetic layers including the 2nd winding unit wound around a direction and opposite direction predetermined [aforementioned] focusing on the magnetic layer of another side of the 1st winding unit [which is wound in the predetermined direction focusing on one magnetic layer of the two aforementioned magnetic layers], and aforementioned two magnetic layers. The insulating layer which insulates the aforementioned thin film coil from the two aforementioned magnetic layers. It is the manufacture method of the magnetic head equipped with the above, and is characterized by forming the aforementioned thin film coil so that the continuum with which the winding unit of the above 1st and the winding unit of the above 2nd were connected by turns may be made by carrying out the laminating of two or more components which constitute the aforementioned thin film coil to order, and forming them in it.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] this invention relates to the magnetic head which writes in at least and has the induction-type MAG sensing element of business, and its manufacture method.
[0002]
[Description of the Prior Art] In recent years, the improvement in a performance of the thin film magnetic head is called for with improvement in the field recording density of a hard disk drive unit. As the thin film magnetic head, the compound-die thin film magnetic head which has the structure which carried out the laminating of the recording head which has an induction-type MAG sensing element for writing, and the reproducing head which has a magnetic-reluctance (it is hereafter described as MR (Magneto Resistive).) element for read-out is used widely, for example.
[0003] A recording head is arranged in the upper and lower sides for example, on both sides of a record gap (write gap), and is constituted including the up magnetic pole (top pole) and lower magnetic pole (bottom pole) which were magnetically connected in the end section, and the coil for magnetic-flux generating. The up magnetic pole and the lower magnetic pole have the same constant width (constant width portion) mutually [near the record gap of the field of the side near the record-medium opposed face (pneumatic bearing side) which faces a magnetic-recording medium (only henceforth a "record medium")], and the "magnetic pole portion" which specifies recording track width of face by these parts is constituted.
[0004] The "helical structure" etc. which winds the circumference of the "spiral structure", up magnetic pole, and lower magnetic pole around which the connection of an up magnetic pole, a lower magnetic pole or an up magnetic pole, and a lower magnetic pole was wound two-dimensional as a center (to inside of 1 flat surface) as structure of a coil, for example is known. the shape of helical one which consisted of JP,5-242429,A as an example which applied such coil structures in the thin film magnetic head equipped with the up magnetism core and lower magnetism core by which opposite arrangement was carried out with the lower stripes-like electric conduction film, the up stripes-like electric conduction film, etc. -- a conductor -- the structure where a coil winds the circumference of an up magnetism core is indicated Moreover, in a utility model No. 3033043, in the thin film magnetic head equipped with the 1st core and the 2nd core by which opposite arrangement was carried out, while winding the circumference of the 1st core in the clockwise direction (or left-handed rotation), the thin film coil layer of the shape of two or more spiral which winds the circumference of the 2nd core in the counterclockwise direction (right-handed rotation) is arranged hierarchical, and the structure where these thin film coil layers of each other were connected is indicated. Moreover, in JP,5-101337,A, the structure where the helical-like coil which winds the circumference of a lower layer thin film magnetic core, and the helical-like coil which winds the circumference of the upper thin film magnetic core were connected through the spiral-like coil is indicated in the thin film magnetic head equipped with the lower layer thin film magnetic core and the upper thin film magnetic core by which opposite arrangement was carried out.

[0005] In the thin film magnetic head, if current flows in a coil at the time of informational record operation, according to this, magnetic flux will occur, for example. The magnetic flux generated at this time is spread via the propagation path (henceforth a "magnetic path") of the magnetic flux constituted by the up magnetic pole and the lower magnetic pole to the constant width portion of the up magnetic pole which constitutes a part of magnetic pole portion. The magnetic flux spread to the constant width portion reaches the point by the side of the pneumatic bearing side further. When the magnetic flux which reached the point of a constant width portion leaks to the exterior near the record gap, the signal magnetic field for record occurs. A record medium is partially magnetized by this signal magnetic field, and information is recorded.
[0006]
[Problem(s) to be Solved by the Invention] By the way, the miniaturization of a coil is called for for the purpose of the miniaturization of the thin film magnetic head in recent years. When the miniaturization of a coil is taken into consideration, the helical structure where the field which a coil occupies is smaller than the spiral structure of having a two-dimensional breadth is suitable as coil structure, and it is thought possible by making between the coils of a coil close to miniaturize coil structure more.
[0007] However, there was a problem that the manufacture yield fell for the following reasons conventionally while manufacture of the thin film magnetic head takes a long time. That is, in order to make between the coils of a coil close for example, that a coil should be miniaturized, a high formation precision is required. In such a case, in order to secure a high formation precision, in order that the manufacturing process of a coil may make it complicated, the time which manufacture of the thin film magnetic head takes becomes long. Moreover, if the formation precision of a coil is not enough or a delicate gap arises for formation precision at the time of coil formation, it may originate in contact between coil coils, a short circuit etc. may arise, and the manufacture yield of the thin film magnetic head may fall. That is, it was difficult to reconcile the miniaturization of a coil, and the improvement in the manufacture yield etc. proper conventionally.
[0008] In addition, the above-mentioned problem is similarly produced in other magnetic heads (for example, head for videotape record reproduction) which have the same structure (the two magnetic substance which counters, and coil for magnetic-flux generating) as this besides the thin film magnetic head.
[0009] this invention was made in view of this trouble, and the purpose is to offer the magnetic head which can raise the manufacture yield, and its manufacture method while shortening production time, miniaturizing a coil.
[0010]
[Means for Solving the Problem] It has two magnetic poles arranged so that a record medium may be faced, while the magnetic head of this invention counters mutually through a gap. The two magnetic substance which extends in this field and the direction to leave from the record-medium opposed face which faces a record medium and which was connected magnetically, The 2nd winding unit wound around a predetermined direction and predetermined opposite direction centering on the magnetic substance of another side of the 1st winding unit and the two magnetic substance which are wound in the predetermined direction centering on one magnetic substance of the two magnetic substance is included. It is the magnetic head which has the coil which extends along the extension direction of the two magnetic substance, and the insulator with which a coil is insulated from the two magnetic substance, and a coil makes the continuum which comes to connect the 1st winding unit and the 2nd winding unit by turns.
[0011] In the magnetic head of this invention, the continuum to which a coil connects the 1st winding unit and the 2nd winding unit with by turns, and makes them is made. Thereby, the rate of the portion which requires a high formation precision among coils decreases.
[0012] You may make it a gap, the two magnetic substance, a coil, and an insulator consist of a thin film at least in the magnetic head of this invention.
[0013] It has two magnetic poles arranged so that a record medium may be faced, while the manufacture method of the magnetic head of this invention counters mutually through a gap layer. Two magnetic layers which extend in this field and the direction to leave from the record-

medium opposed face which faces a record medium and which were connected magnetically, The 2nd winding unit wound around a predetermined direction and predetermined opposite direction the 1st winding unit wound in the predetermined direction focusing on one magnetic layer of the two magnetic layers and focusing on the magnetic layer of another side of the two magnetic layers is included. It is the manufacture method of the thin film magnetic head of having the insulating layer which insulates a thin film coil with the thin film coil which extends along the extension direction of two magnetic layers from two magnetic layers. By carrying out the laminating of two or more components which constitute a thin film coil to order, and forming them in it, a thin film coil is formed so that the continuum with which the 1st winding unit and the 2nd winding unit were connected by turns may be made.
[0014] By the manufacture method of the magnetic head of this invention, by carrying out the laminating of two or more components which constitute a thin film coil to order, and forming them in it, a thin film coil is formed so that the continuum with which the 1st winding unit and the 2nd winding unit were connected by turns may be made.
[0015]
[Embodiments of the Invention] Hereafter, the gestalt of operation of this invention is explained in detail with reference to a drawing.
[0016] First, with reference to drawing 1 - drawing 22 , the manufacture method of the compound-die thin film magnetic head as the manufacture method of the thin film magnetic head concerning the gestalt of 1 operation of this invention is explained. In addition, since it is embodied by the manufacture method of the thin film magnetic head concerning the gestalt of this operation, it combines below and the thin film magnetic head concerning the gestalt of this operation is explained.
[0017] In drawing 1 - drawing 12 , (A) shows cross-section structure perpendicular to a pneumatic bearing side, and (B) shows cross-section structure parallel to the pneumatic bearing side of a magnetic pole portion. The tropia structure and drawing 21 to manufacturing processes with main drawing 13 - drawing 20 simplify the structure of the thin film coil 9 in a completion state to one line, and the tropia structure in the completion state of the thin film coil 9, the lower magnetic pole 13, and the up magnetic pole 17 and drawing 22 express them. Here, in drawing 13 - drawing 20 , in drawing 13 , drawing 2 and drawing 14 correspond to drawing 4 , and drawing 15 corresponds to the state where drawing 8 and drawing 19 were shown in drawing 9 , and drawing 5 and drawing 16 showed [drawing 6 and drawing 17] drawing 20 to drawing 10 for drawing 7 and drawing 18 , respectively. (A) of above-mentioned drawing 2 - drawing 10 is equivalent to the view cross section which met the A-A line in drawing 13 - drawing 20 .
[0018] While writing "length (or the length direction)" and writing "thickness (or the thickness direction)", X shaft orientations in each drawing of drawing 1 - drawing 22 in the following explanation ["width of face (or cross direction)" and Y shaft orientations] [Z shaft orientations] The pneumatic bearing side 20 side (or side which serves as the pneumatic bearing side 20 in a back process) among Y shaft orientations "anterior (it shall write "a posterior (or back)") [or the front" and its opposite side]
[0019] By the manufacture method of the thin film magnetic head of the gestalt the <manufacture method of the thin film magnetic head> book operation, first, as shown in drawing 1 , the insulating layer 2 which consists of an aluminum oxide (it is only called an "alumina" below aluminum2 O3;.) is deposited by the thickness of about 3.0 micrometers - about 5.0 micrometers on the substrate 1 which consists of ARUTIKKU (aluminum 2O3 and TiC). Next, the lower shield layer 3 which consists for example, of a ferronickel alloy (it is only called "permalloy (tradename) below NiFe:.") is alternatively formed by the thickness of about 2.0 micrometers by the frame galvanizing method mentioned later on an insulating layer 2.
[0020] Next, as shown in drawing 1 , the shield gap film 4 which consists of an alumina is formed by the thickness of about 0.01 micrometers - 0.1 micrometers by sputtering on the lower shield layer 3. Next, on the shield gap film 4, it forms so that it may become the pattern configuration of a request of the MR film 5 for constituting MR element by highly precise photolithography processing. Next, the lead layer (not shown) as a drawer electrode layer which connects with the MR film 5 electrically is alternatively formed by highly precise photolithography processing. Next,

the shield gap film 6 is formed so that the MR film 5 may be covered by the same technique as the case where the shield gap film 4 is formed, and MR film 5 grade is laid underground in the shield gap film 4 and 6.
[0021] Next, the up shield layer 7 which consists of a permalloy is alternatively formed by the thickness of about 1.0 micrometers - 2.0 micrometers for example, by the frame galvanizing method on the shield gap film 4 and 6.
[0022] Next, as shown in drawing 2 and drawing 13 , the insulator layer 8 which consists of an alumina is alternatively formed by the thickness of about 0.1 micrometers - 0.2 micrometers by sputtering on the up shield layer 7. In case an insulator layer 8 is formed, it is made not to cover the field (opening 7K) in which other up shield layers 10 (refer to drawing 3) will be formed in a back process.
[0023] Next, as shown in drawing 2 and drawing 13 , two or more coil parts 9A (for example, nine A1, nine A2, nine A3) which consists of copper (Cu) is alternatively formed by the thickness of about 1.0 micrometers - 1.5 micrometers for example, by the frame galvanizing method on an insulator layer 8. This coil parts 9A will constitute some thin film coils 9 (refer to drawing 10 and drawing 21) mentioned later, and as shown in drawing 13 , it has the band-like flat-surface configuration where the rectangle was made. In case coil parts 9A is formed, it connects with a series of coil parts (9B, 9C, 9D, 9E) formed in a back process, and alignment is carried out so that the thin film coil 9 may finally be formed as the aggregate of these coil parts. More specifically, the longitudinal direction of coil parts 9A arranges so that it may incline to the cross direction (X shaft orientations in drawing). In addition, the flat-surface configuration of coil parts 9A can not necessarily be changed not only in the shape of a rectangle, but freely. Moreover, the arrangement number of coil parts 9A can be freely changed according to the number of winding (number of turns) of the thin film coil 9 to the lower magnetic pole 13 and the up magnetic pole 17 (refer to drawing 8) mentioned later mentioned later.
[0024] In case coil parts 9A is formed by the frame galvanizing method, the electrode layer used as the seed layer in the electrolysis galvanizing method is first formed by sputtering on an insulator layer 8. As a formation material of an electrode layer, the formation material of coil parts 9A, the same material (copper), etc. are used, for example. Next, after applying a photoresist and forming a photoresist film on the above-mentioned electrode layer, the photo mask for exposure is alternatively formed on this photoresist film. In case a photo mask is formed, while making it have a flat-surface configuration corresponding to the flat-surface configuration of coil parts 9A, alignment is carried out so that it may correspond to the formation position of coil parts 9A. Next, after performing exposure processing to a photoresist film using a photo mask, the framework (frame pattern) for forming coil parts 9A is alternatively formed by developing this photoresist film. Next, while using a frame pattern as a mask, coil parts 9A is alternatively formed by carrying out plating growth of the copper by the electrolysis galvanizing method, using the electrode layer formed in the point process as a seed layer. Finally, a frame pattern is removed after forming coil parts 9A.
[0025] Next, as shown in drawing 3 , the up shield layer 10 which consists of a permalloy is alternatively formed in opening 7K by the thickness of about 2.5 micrometers - 3.0 micrometers for example, by the frame galvanizing method. Next, precursive insulator layer 11P which consist of an alumina are formed by the thickness of about 3.0 micrometers - 4.0 micrometers by sputtering so that the concavo-convex field constituted by coil parts 9A and the up shield layer 10 grade may be covered. These precursive insulator layer 11P are a pre-preparation layer used as an insulator layer 11 by performing polish processing in a back process.
[0026] Next, for example by grinding and carrying out flattening of the whole by the CMP (chemical machinery polish) method, as shown in drawing 4 and drawing 14 , the insulator layer 11 which lays coil parts 9A etc. underground is formed. It is made to perform polish processing until the up shield layer 10 is exposed at least, in case an insulator layer 11 is formed.
[0027] next, the thing which it **********s alternatively and delves into for a portion [near the both ends of coil parts 9A (nine A1, nine A2, nine A3)] among insulator layers 11 by reactive ion etching (it is only called "RIE" below Reactive Ion Etching;.) as shown in drawing 14 -- for example, two or more connection hole 11H which have a circular opening configuration are

formed It is made to perform etching processing until coil parts 9A is exposed, in case connection hole 11H are formed. These connection hole 11H are for connecting coil parts 9A and coil parts 9B (referring to drawing 17 and drawing 21) formed in a back process. In addition, the opening configuration of connection hole 11H cannot necessarily be restricted circularly, but can be changed freely.

[0028] Next, as shown in drawing 5 and drawing 15 , the insulator layer 12 which consists of an alumina is formed in the whole by the thickness of about 0.1 micrometers - 0.2 micrometers by sputtering. In case an insulator layer 12 is formed, it is made not to cover connection hole 11H formed in the point process, as shown in drawing 15 .

[0029] Next, as shown in drawing 5 and drawing 15 , the lower magnetic pole 13 which consists of a permalloy by the frame galvanizing method so that all coil parts 9A may be crossed is alternatively formed by the thickness of about 2.0 micrometers - 3.0 micrometers on the field surrounded by connection hole 11H group among insulator layers 12. In case the lower magnetic pole 13 is formed, it is made for point 13A and back end section 13B to be included sequentially from the side (left-hand side in drawing) which serves as the pneumatic bearing side 20 in a back process, as shown in drawing 15 . It is made for width of face to narrow as back end section 13B has the width of face of simultaneously regularity in the back section and approaches point 13A in the front section, while making it point 13A have the very minute constant width which specifies recording track width of face as structure of the concrete lower magnetic pole 13, for example. Here, the lower magnetic pole 13 corresponds to one example of "one magnetic substance" in this invention, or a "one magnetic layer."

[0030] Next, as shown in drawing 6 and drawing 16 , the record gap layer 14 which consists of an alumina is formed in the whole by the thickness of about 0.1 micrometers - 0.3 micrometers by sputtering. In case the record gap layer 14 is formed, it is made not to cover opening 14K for connecting the lower magnetic pole 13 and the up magnetic pole 17 (referring to drawing 8) formed in a back process. Here, the record gap layer 14 corresponds to one example of the "gap" in this invention, or a "gap layer."

[0031] Next, on the record gap layer 14, by highly precise photolithography processing, organic insulating materials, such as the material which shows a fluidity at the time of heating, for example, a photoresist etc., are formed so that it may become a predetermined pattern. Next, it heat-treats to this photoresist film at the temperature of about 200 degrees C-250 degreeC within the limits. Of this heat-treatment, as shown in drawing 6 and drawing 16 , an insulator layer 15 is formed alternatively. This insulator layer 15 mainly insulates electrically between the lower magnetic pole 13 and coil parts 9C formed in a back process. When a photoresist flows at the time of heating, it makes roundish [wore] near the edge of an insulator layer 15. While carrying out alignment so that it may correspond to the arrangement field of coil parts 9C (refer to drawing 7 and drawing 17) formed for example, in a back process in case an insulator layer 15 is formed, it is made not to cover connection hole 11H formed in the point process, and opening 14K, as shown in drawing 16 .

[0032] Next, as shown in drawing 17 , two or more coil parts 9B which will constitute some thin film coils 9 is alternatively formed into connection hole 11H by the electrolysis galvanizing method by growing up the plating film which consists of copper. This coil parts 9B is formed as shown in drawing 21 , for example, so that pillar-like structure may be made corresponding to the internal structure of connection hole 11H.

[0033] Next, as shown in drawing 7 and drawing 17 , two or more coil parts 9C (for example, 9C1, 9C2, 9C3, 9C4, 9C5, 9C6, 9C7) which consists of copper is alternatively formed by the thickness of about 1.5 micrometers by the same frame galvanizing method as the case where coil parts 9A is formed. While making it coil parts 9C more specifically have the band-like flat-surface configuration where the rectangle was made, it is made for the longitudinal direction of coil parts 9C to intersect perpendicularly mostly to the length direction (Y shaft orientations in drawing). In case coil parts 9C is formed, while the end of the coil parts 9C1 and the end of the coil parts nine A1 are connected through coil parts 9B The other end of the coil parts 9C2 and the other end of the coil parts nine A1 are connected through coil parts 9B, and the connection unit constituted by a series of coil parts groups (9C1, 9B, nine A1, 9B, 9C2) is formed. And a

connection unit is similarly formed about other coil parts groups (9C3, 9B, nine A2, 9B, 9C4 and 9C5, 9B, nine A3, 9B, 9C6). Each connection unit (coil parts 9A, 9B, and 9C) will wind the circumference of the lower magnetic pole 13 (back end section 13B), as shown in drawing 21 . Especially in the following, the connection unit constituted with the coil parts 9A, 9B, and 9C shall be called "the 1st winding unit U1" (refer to drawing 22).

[0034] Next, as shown in drawing 8 and drawing 18 , the insulator layer 16 which consists of a photoresist is formed, using the same material as the case where an insulator layer 15 is formed, and the formation method so that coil parts 9C and its boundary region may be covered. Coil parts 9C is laid underground by the insulator layer 16.

[0035] Next, as shown in drawing 8 and drawing 18 , the up magnetic pole 17 which consists of a permalloy is alternatively formed by the thickness of about 2.0 micrometers - 3.0 micrometers for example, by the frame galvanizing method on the field from the side which serves as the pneumatic bearing side 20 in a back process to opening 14K. In case the up magnetic pole 17 is formed, it has the almost same structure (point 17A, back end section 17B) as the lower magnetic pole 13 (point 13A, back end section 13B), and is made to counter with the lower magnetic pole 13 in the thickness direction (Z shaft orientations in drawing), as shown in drawing 18 . The lower magnetic pole 13 and the up magnetic pole 17 are magnetically connected in opening 14K, and a magnetic path is formed of the lower magnetic pole 13 and the up magnetic pole 17. When point 13A and point 17A which have the very minute constant width which specifies recording track width of face counter through the record gap layer 14, the magnetic pole portion 100 is formed (refer to drawing 8 (B)). Here, the up magnetic pole 17 corresponds to one example of "the magnetic substance of another side" in this invention, or "the magnetic layer of another side."

[0036] Next, as shown in drawing 9 and drawing 19 , the insulator layer 18 which consists of a photoresist is alternatively formed on the up magnetic pole 17, using the same material as the case where an insulator layer 15 is formed, and the formation method. This insulator layer 18 insulates electrically between the up magnetic pole 17 and coil parts 9E formed in a back process. In case an insulator layer 18 is formed, alignment is carried out so that it may correspond to the arrangement field of coil parts 9E (refer to drawing 10 and drawing 20) formed in a back process. Here, the insulator constituted by insulator layers 11, 12, 15, 16, and 18 corresponds to the "insulator" in this invention, or one example of a "insulating layer."

[0037] Next, as shown in drawing 19 , two or more connection hole 18H which have a circular opening configuration, for example are formed by **********ing alternatively and investigating a portion [near / in which coil parts 9B in the coil parts 9C1 to 9C6 is not arranged among insulator layers 16 and 18 and the up magnetic pole 17 / the near edge], and a portion / near the ends of the coil parts 9C7]. It is made to perform etching processing until coil parts 9C is exposed, in case connection hole 18H are formed. These connection hole 18H are for mainly connecting coil parts 9C and coil parts 9D (referring to drawing 20 and drawing 21) formed in a back process.

[0038] Next, as shown in drawing 20 , two or more coil parts 9D is alternatively formed into connection hole 18H by the electrolysis galvanizing method by growing up the plating film which consists of copper. As shown in drawing 21 , this coil parts 9B is formed like coil parts 9B formed in the point process so that pillar-like structure may be made corresponding to the internal structure of connection hole 18H.

[0039] Next, as shown in drawing 10 and drawing 20 , two or more coil parts 9E (for example, nine E1, nine E2, nine E3) which consists of copper is alternatively formed by the thickness of about 1.5 micrometers for example, by the frame galvanizing method on an insulator layer 18. In case coil parts 9E is formed, while the end of the coil parts nine E1 and the end of the coil parts 9C2 are connected through coil parts 9D The other end of the coil parts nine E1 and the other end of the coil parts 9C3 are connected through coil parts 9D, and the connection unit constituted by a series of coil parts groups (9C2, 9D, nine E1, 9D, 9C3) is formed. And a connection unit is similarly formed about other coil parts groups (9C4, 9D, nine E2, 9D, 9C5 and 9C6, 9D, nine E3, 9D, 9C7). Each connection unit (coil parts 9C, 9D, and 9E) will wind the circumference of the up magnetic pole 17 (back end section 17B), as shown in drawing 21 .

Especially in the following, the connection unit constituted with the coil parts 9C, 9D, and 9E shall be called "the 2nd winding unit U2" (refer to drawing 22). In addition, in case the thin film coil 9 is formed, in order to equate the yield of the magnetic flux in each circumference field of the lower magnetic pole 13 and the up magnetic pole 17, and the generating timing of magnetic flux mentioned later, it is desirable to make it make in agreement the number of the 1st winding units U1 and the number of the 2nd winding units U2 (refer to drawing 22).

[0040] By forming coil parts 9E, the thin film coil 9 is formed as the aggregate of a series of coil parts (9A, 9B, 9C, 9D, 9E). In case coil parts 9E is formed, while forming lead-wire 9F1 so that it may connect with coil parts 9DF formed in the other end of the coil parts 9C1, lead-wire 9F2 are simultaneously formed, for example so that it may connect with coil parts 9DR formed in the end section of the coil parts 9C7. As a formation material of lead-wire 9F1 and 9F2, copper etc. is used like the thin film coil 9, for example.

[0041] Next, as shown in drawing 11 , the overcoat layer 19 which consists of inorganic insulating materials, such as an insulating material, for example, an alumina etc., is formed by the thickness of about 20 micrometers - 40 micrometers so that the whole may be covered.

[0042] Finally, as shown in drawing 12 , the pneumatic bearing side 20 of a recording head and the reproducing head is formed according to machining or a polish process, and the thin film magnetic head is completed.

[0043] With reference to <the structure of the thin film magnetic head> next drawing 12 , drawing 21 , and drawing 22 , the structure of the thin film magnetic head concerning the form of this operation is explained.

[0044] As shown in drawing 12 , the position of the front end of an insulator layer 15 is the position used as the criteria at the time of determining the throat height (TH) which is one of the factors which determines the performance of a recording head, i.e., a throat height zero position, (TH0 position). Throat height (TH) is specified as length from the position (TH0 position) of the front end of an insulator layer 15 to the pneumatic bearing side 20.

[0045] As shown in drawing 21 and drawing 22 , the thin film coil 9 is constituted as the aggregate of a series of coil parts (9A, 9B, 9C, 9D, 9E) by which laminating formation was carried out, as described above. From the pneumatic bearing side 20, this thin film coil 9 continues by turns, and includes the 1st winding unit U1 and the 2nd winding unit U2, and the continuum which extends while coiling around the lower magnetic pole 13 (back end section 13B) and the up magnetic pole 17 (back end section 17B) by turns is made. Specifically per [U1] 1st winding, the thin film coil 9 is winding [the thin film coil 9] in the clockwise direction in the counterclockwise direction focusing on the up magnetic pole 17 per [2] winding and 2nd winding focusing on the lower magnetic pole 13. That is, the orbit of the thin film coil 9 seen from the pneumatic bearing side 20 side draws the character of "8" (refer to drawing 22). Suppose that the structure of the thin film coil 9 is especially called "balance volume structure" in the following explanation paying attention to the point that a coil mainly coils around the both sides of the lower magnetic pole 13 and the up magnetic pole 17 equally (often [balance]). It connects with the external circuit which is not illustrated and both lead-wire 9F1 connected to the both ends of the thin film coil 9 and 9F2 can make it flow through the thin film coil 9 by this external circuit now.

[0046] With reference to <operation of the thin film magnetic head> next drawing 12 , drawing 21 , and drawing 22 , operation of the thin film magnetic head concerning the form of this operation is explained.

[0047] In this thin film magnetic head, if Current I flows in the thin film coil 9 toward lead-wire 9F1 to 9F2 through the external circuit which is not illustrated at the time of informational record operation, magnetic flux J will occur according to this. At this time, per [U1] 1st winding, the flow of the magnetic flux J which spreads the inside of the lower magnetic pole 13 toward back when Current I flows arises so that it may wind in the clockwise direction, and when Current I flows per [U2] 2nd winding on the other hand so that it may wind in the counterclockwise direction, the flow of the magnetic flux J which spreads the inside of the up magnetic pole 17 toward the front arises. Thereby, the magnetic flux generated with the thin film coil 9 spreads the inside of a magnetic path toward the up magnetic pole 17 (point 17A) from the

lower magnetic pole 13, and, finally reaches a part for the point by the side of the pneumatic bearing side 20 of point 17A. By the magnetic flux which reached a part for the point of point 17A, the signal magnetic field for record occurs in the about 14 record gap layer exterior. In addition, by passing Current I to an opposite direction toward lead-wire 9F2 to 9F1, magnetic flux spreads the inside of a magnetic path toward the lower magnetic pole 13 from the up magnetic pole 17, and the case where it is the above, and the signal magnetic field of a retrose occur. By these signal magnetic fields, a magnetic-recording medium can be magnetized partially and information can be recorded.

[0048] On the other hand, sense current is passed on the MR film 5 at the time of informational reproduction operation. Since the resistance of the MR film 5 changes according to the regenerative-signal magnetic field from a magnetic-recording medium, it can read the information currently recorded on the magnetic-recording medium by detecting the resistance change by change of sense current.

[0049] With reference to <an operation and effect> of the form of this operation next drawing 12 , and drawing 23 , an operation and effect of the form of this operation are explained. Drawing 23 expresses the cross-section composition of the thin film magnetic head as an example of comparison over the thin film magnetic head of the form of this operation, and corresponds to drawing 12 . Drawing 23 shows the case where it, for example, has the helical structure where the thin film coil 99 winds the circumference of the up magnetic pole 17 (yoke section 17B). With the form of this operation, since it was made to have the balance volume structure which extends along the extension direction of the lower magnetic pole 13 and the up magnetic pole 17 as shown in drawing 12 while the thin film coil 9 continued by turns and included the 1st winding unit U1 and the 2nd winding unit U2, while shortening the time which manufacture of the thin film magnetic head takes for the following reasons, the manufacture yield can be raised.

[0050] That is, in order to realize the miniaturization of the thin film magnetic head, it is necessary to make between the coils of a coil close and to miniaturize a thin film coil. However, since each distance D1 between coils will become small if between coil coils is made close while an advantage is acquired in the point of being smaller than the case where the field (occupancy field) which a coil occupies has spiral structure, when manufacturing the thin film magnetic head (refer to drawing 23) as an example of comparison in which the thin film coil 99 which has helical structure was carried, a high formation precision is required on the occasion of formation of the thin film coil 99. In such a case, if the formation precision of the thin film coil 99 is not enough or a delicate gap arises for formation precision at the time of thin film coil 99 formation, it may originate in contact between coil coils, a short circuit etc. may arise, and the manufacture yield of the thin film magnetic head may fall.

[0051] Here, as the technique of forming the thin film coil 99 with high precision, there is the method of carrying out flattening of the front face of the ground in the formation field of the thin film coil 99 using polish processing, for example. Since it will originate in the reflected light reflected in the direction of slant, or a longitudinal direction from the front face of a ground in the exposure process for forming a frame pattern and the formation precision of a frame pattern will fall if the front face of a ground is making irregularity in case a thin film coil is formed for example, using the frame galvanizing method, this suppresses the bad influence by the reflected light by grinding and carrying out flattening of the front face of a ground. However, since the number of manufacturing processes will increase if polish processing is performed, the time which manufacture of the thin film magnetic head takes will become long. That is, in the case of the example of comparison, it was difficult to reconcile the miniaturization of the thin film coil 99, and the improvement in the manufacture yield etc.

[0052] On the other hand, although the distance D2 (about D 2= D1) between coil parts 9C narrows with the form of this operation according to the miniaturization of a coil as shown in drawing 12 , distance with sufficient distance D3 between coil parts 9A and distance D4 (about D 3= D4) between coil parts 9E is secured. In such a case, although a high formation precision is required about formation of coil parts 9C, formation precision to the extent that it requires for formation of coil parts 9C about formation of the coil parts 9A and 9E is not needed. Therefore, with the form of this operation, rather than the case of the above-mentioned example of

comparison, in order that the rate of the portion as which a high formation precision is required among the thin film coils 9 may decrease (when forming the thin film coil 99), possibility that faults, such as a short circuit, will arise falls and the manufacture yield of a thin film coil improves. And although the field (occupancy field) which the thin film coil 9 which has balance volume structure occupies becomes large a little rather than the occupancy field of the thin film coil (for example, thin film coil 99) which has helical structure, since the occupancy field becomes small sharply compared with the thin film coil which has spiral structure, the miniaturization of the thin film coil 9 can also realize it.

[0053] Furthermore, with the form of this operation, since it is not necessary to perform polish processing to formation of the coil parts 9A and 9E in the formation process of these parts based on not requiring a high formation precision, by easy-izing formation of the thin film coil 9, the number of manufacturing processes can be cut down and the time which manufacture of the thin film magnetic head takes can be shortened. That is, unlike the thin film magnetic head (JP,5-242429,A, a utility model No. 3033043, JP,5-101337,A) illustrated in the term of a Prior art, in the form thin film magnetic head of this operation, the miniaturization of a coil and the improvement in the manufacture yield etc. can be reconciled proper.

[0054] Moreover, with the form of this operation, it has an advantage also in the viewpoint concerning suppression of generating of the noise component resulting from the generating timing of magnetic flux. The structure of the thin film magnetic head as other examples of comparison as opposed to [as opposed to / the structure of the thin film magnetic head of the form of this operation / in drawing 24] the thin film magnetic head of the form of this operation in drawing 25 is shown typically, respectively. The thin film coil 109 (for example, six numbers of turns) shown in drawing 25 has helical structure, and is making the continuum with which winding unit U3A, U3B and U3C which wind the circumference of the lower magnetic pole 13 along the extension direction, and winding unit U4A which winds the circumference of the up magnetic pole 17 along the extension direction, U4B and U4C were connected. With this thin film coil 109, the generating state of the magnetic flux at the time of passing current becomes unequal. Namely, if current is passed in the thin film coil 209, the generating field of magnetic flux will shift in order of winding unit U3A, U3B, U3C, U4C, U4B, and U4A. After magnetic flux occurs in the field (U3A, U3B, U3C) of the lower magnetic pole 13, magnetic flux will occur in the field (U4A, U4B, U4C) of the up magnetic pole 17. In such a case, since the generating timing of magnetic flux differs greatly by the lower magnetic pole 13 and the up magnetic pole 17, movement of an uneven magnetic domain wall will arise and light after noises, such as a popcorn noise, will occur.

[0055] On the other hand, with the form (refer to drawing 24) of this operation, supposing it has the same number of turns (6 times) as the thin film coil 109, the generating field of magnetic flux shifts in order of U1A, U2A, U1B, U2B, U1C, and U2C, and the generating timing of magnetic flux is equated as the whole magnetic pole including the lower magnetic pole 13 and the up magnetic pole 17. Thereby, unlike the case of the above-mentioned example of comparison, generating of light after noises, such as popcorn, can be suppressed.

[0056] Moreover, with the form of this operation, when the thin film coil 9 has balance volume structure, it will also have an advantage of stabilization of a recording characteristic besides suppression of generating of the above-mentioned noise component. Drawing 26 shows typically the structure of the thin film magnetic head as an example of comparison of further others over the thin film magnetic head of the form of this operation, and the thin film coil 209 has for example, spiral structure. the amount J2 of magnetic flux held in the magnetic-path component part to the amount J1 of magnetic flux generated with the thin film coil 209 which has spiral structure, the hold efficiency 209, i.e., the thin film coil, of magnetic flux J to a magnetic-path component part (the lower magnetic pole 13, up magnetic pole 17), -- comparatively (J2/J1) -- not being enough . Because, the magnetic flux J generated among the magnetic flux J generated with the thin film coil 209 more back than the lower magnetic pole 13 and the up magnetic pole 17 is the shell which is hard to hold in a magnetic-path component part.

[0057] On the other hand, with the form (refer to drawing 24) of this operation, since all the portions of the thin film coil 9 approach the lower magnetic pole 13 and the up magnetic pole 17 and are winding the circumference, the magnetic flux J generated with the thin film coil 9 is fully

held in a magnetic-path component part, and the hold efficiency of the magnetic flux J to a magnetic-path component part improves. Thereby, the flux density in point 13A of the up magnetic pole 13 increases, and the stable recording characteristic can be secured.
[0058] Moreover, with the form of this operation, it has an advantage also in the viewpoint of the RF response characteristic of the thin film magnetic head. That is, generally, the RF response characteristic of the thin film magnetic head improves, so that the coil inductance of a thin film coil becomes small. It is known that the coil inductance of a thin film coil will decrease as the radius (coil radius) of the portion which makes the shape of a ring of for example, the thin film coils becomes small. With the thin film coil 209 (refer to drawing 26) which has spiral structure, since a coil radius increases according to the increase in the number of turns of a coil, a coil inductance will become large and a RF response characteristic will deteriorate. On the other hand, with the thin film coil 9 (refer to drawing 24) of the form of this operation, since a coil radius is maintained when a coil radius becomes small and the number of turns of a coil is made to increase from the case of the thin film coil 209, a coil inductance can be made small and a RF response characteristic can be raised.
[0059] This is clear from the experimental result about the excitation magnetic influence of the thin film magnetic head shown in drawing 27 . Drawing 27 is an experimental result about the standup property of the excitation magnetic field L. The "horizontal axis" in drawing expresses Time T, a "vertical axis" expresses excitation magnetic-field-strength L, respectively, and the thin film magnetic head (refer to drawing 24) of the form of this operation which carried the thin film coil 9 with which "A" has balance volume structure, and "B" express the property of the thin film magnetic head (refer to drawing 26) as an example of comparison of having carried the thin film coil which has spiral structure, respectively. In addition, the yield of the magnetic flux in the thin film magnetic head of "A" and "B" is the same. As shown in drawing 27 , the standup inclination of the excitation magnetic field L in the thin film magnetic head (A) of the form of this operation is steeper than the standup inclination of the excitation magnetic field L in the thin film magnetic head (B) as an example of comparison, and it is stabilized more for a short time.
[0060] In addition, although the thin film coil 9 was constituted from a form of this operation as the aggregate of five kinds of coil parts (9A-9E), it is not necessarily restricted to this and the number of the kinds of coil parts which constitute the thin film coil 9 can be changed freely. As shown in drawing 28 , while carrying out "9G" of the coil parts 9B and 9C and specifically forming them really, it really forms, using the coil parts 9D and 9E as "9H", and the thin film coil 9 may be made to be constituted by three kinds of call parts (9A, 9G, 9H). Since the number of manufacturing processes which formation of the thin film coil 9 takes by lessening the coil number of multipart forms is cut down, the time which manufacture of the thin film magnetic head takes can be shortened. In addition, structures other than the above in the thin film magnetic head shown in drawing 28 are the same as that of the case of drawing 21 .
[0061] Moreover, although it was made for the thin film coil 9 to wind [in / winding and the 2nd winding unit U2 / in the thin film coil 9] in the clockwise direction in the counterclockwise direction focusing on the up magnetic pole 17 focusing on the lower magnetic pole 13 in the 1st winding unit U1 with the gestalt of this operation as shown in drawing 21 and drawing 22 It is not necessarily restricted to this and may be made to make reverse the winding direction of the thin film coil 9 in the 1st winding unit U1 and the 2nd winding unit U2. Also in this case, the same effect as the case of the gestalt of the above-mentioned implementation can be acquired.
[0062] Moreover, with the gestalt of this operation, although the thin film coil 9 wound the circumference of the up magnetic pole 17 for the circumference of the lower magnetic pole 13 in winding and the 2nd winding unit U2 in the 1st winding unit U1 It is not necessarily restricted to this and you may make it wind the circumference of the lower magnetic pole 13 for the circumference of the up magnetic pole 17 in winding and the 2nd winding unit U2 in the 1st winding unit U1.
[0063] Moreover, with the gestalt of this operation, as for the number of winding of the thin film coil 9 in each winding unit (U1, U2), the thin film coil 9 can change the circumference of the up magnetic pole 17 freely, although the thin film coil 9 wound [in / 1 time winding and the 2nd winding unit U2 / on the 1st winding unit U1 and] the circumference of the lower magnetic pole

13 once. It is good also as multiple times and the number of winding in the 1st winding unit U1 and the 2nd winding unit U2 may be made for the number of winding to specifically differ from the 1st winding unit U1 per [U2] 2nd winding. However, as described above, it is [that the yield of the magnetic flux in the lower magnetic pole 13 circumference and the yield of the magnetic flux in the up magnetic pole 17 circumference should be made equal] desirable, when changing the number of winding of the thin film coil 9 to make the same the total number of winding in the 1st winding unit U1 and the total number of winding in the 2nd winding unit U2.

[0064] As mentioned above, although the gestalt of operation was mentioned and this invention was explained, this invention is not limited to the gestalt of the above-mentioned implementation, and can deform variously. For example, although the gestalt of the above-mentioned implementation explained the case where the coil structure (balance volume structure) of this invention was applied to the thin film coil carried by the thin film magnetic head, it is not necessarily restricted to this and can apply to other magnetic heads (for example, video head etc.) which have the same structure (the two magnetic substance which counters, and coil for magnetic-flux generating) as others and this and a mechanism (record, reproduction) of operation. [magnetic head / thin film] Also in this case, the same effect as the case of the gestalt of the above-mentioned implementation can be acquired.

[0065] Moreover, although the form of the above-mentioned implementation explained the case where the thin film coil 9 had only balance volume structure, it is not necessarily restricted to this and you may make it the thin film coil 9 include others and spiral structure or helical structure. [structure / balance volume] Of course, you may make it the thin film coil 9 include balance volume structures, spiral structures, and all the helical structures.

[0066] moreover, the flat-surface configuration of a series of components containing the lower magnetic pole 13 and the up magnetic pole 17 in a form of the above-mentioned implementation cannot necessarily be restricted to what was shown in drawing 15 or drawing 18 , it can be alike to secure the function of each component as much as possible, it can set, and the flat-surface configuration of a series of components can be changed freely

[0067] Moreover, that the formation method, formation material, etc. concerning formation of a series of components which constitute the thin film magnetic head reproduce the structural feature, the quality-of-the-material-feature, etc. of not only a thing but each component of having not necessarily explained in the form of the above-mentioned implementation can deform freely the formation method of a series of components, formation material, etc. as much as possible.

[0068] Moreover, for example, with the form of the above-mentioned implementation, although the compound-die thin film magnetic head was explained, this invention is applicable also to the thin film magnetic head which has the thin film magnetic head only for records and the induction-type MAG sensing element of record / reproduction combination which have an induction-type MAG sensing element for writing. Moreover, this invention is applicable also to the thin film magnetic head of the structure where read with the element for writing and the built-up sequence of the element of business was reversed.

[0069]

[Effect of the Invention] Since the coil made the continuum which comes to connect the 1st winding unit and the 2nd winding unit by turns according to the magnetic head according to claim 1 or 2 as explained above, the rate of the portion which requires a high formation precision among coils decreases. Therefore, the manufacture yield can be raised while being able to shorten the time which manufacture of the magnetic head takes, miniaturizing a coil.

[0070] Since the continuum with which a thin film coil comes to connect the 1st winding unit and the 2nd winding unit by turns was made especially according to the manufacture method of the magnetic head according to claim 2 or the thin film magnetic head according to claim 3, the rate of the portion which requires a high formation precision among thin film coils decreases. Therefore, the manufacture yield can be raised while being able to shorten the time which manufacture of the thin film magnetic head takes, miniaturizing a thin film coil.

[Translation done.]

* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is a cross section for explaining one process in the manufacture method of the thin film magnetic head concerning the gestalt of 1 operation of this invention.
[Drawing 2] It is a cross section for explaining the process following drawing 1 .
[Drawing 3] It is a cross section for explaining the process following drawing 2 .
[Drawing 4] It is a cross section for explaining the process following drawing 3 .
[Drawing 5] It is a cross section for explaining the process following drawing 4 .
[Drawing 6] It is a cross section for explaining the process following drawing 5 .
[Drawing 7] It is a cross section for explaining the process following drawing 6 .
[Drawing 8] It is a cross section for explaining the process following drawing 7 .
[Drawing 9] It is a cross section for explaining the process following drawing 8 .
[Drawing 10] It is a cross section for explaining the process following drawing 9 .
[Drawing 11] It is a cross section for explaining the process following drawing 10 .
[Drawing 12] It is a cross section for explaining the process following drawing 11 .
[Drawing 13] It is a plan corresponding to the state which showed in drawing 2 .
[Drawing 14] It is a plan corresponding to the state which showed in drawing 4 .
[Drawing 15] It is a plan corresponding to the state which showed in drawing 5 .
[Drawing 16] It is a plan corresponding to the state which showed in drawing 6 .
[Drawing 17] It is a plan corresponding to the state which showed in drawing 7 .
[Drawing 18] It is a plan corresponding to the state which showed in drawing 8 .
[Drawing 19] It is a plan corresponding to the state which showed in drawing 9 .
[Drawing 20] It is a plan corresponding to the state which showed in drawing 10 .
[Drawing 21] It is a perspective diagram showing the completion state of a thin film coil, a lower magnetic pole, and an up magnetic pole.
[Drawing 22] It is drawing which simplifies and expresses the structure of a thin film coil.
[Drawing 23] It is a cross section showing the structure of the thin film magnetic head as an example of comparison over the thin film magnetic head of the gestalt of this operation.
[Drawing 24] It is drawing which expresses typically the structure of the thin film magnetic head of the gestalt of this operation.
[Drawing 25] It is drawing which expresses typically the structure of the thin film magnetic head as other examples of comparison over the thin film magnetic head of the gestalt of this operation.
[Drawing 26] It is drawing which expresses typically the structure of the thin film magnetic head as an example of comparison of further others over the thin film magnetic head of the gestalt of this operation.
[Drawing 27] It is drawing showing the experimental result about excitation magnetic influence.
[Drawing 28] It is a perspective diagram showing the modification concerning the structure of the thin film magnetic head of the gestalt of this operation.
[Description of Notations]
1 [-- 4 A lower shield layer 6 / -- Shield gap film,] -- 2 A substrate, 11 -- An insulating layer, 3 5 [-- Insulator layer,] -- 7 MR film, 10 -- An up shield layer, 8, 12, 15, 16, 18 9 99,109,209 --

A thin film coil, 9A (nine A1, nine A2, nine A3), 9B, 9C (9C1, 9C2, 9C3, 9C4, 9C5, 9C6, 9C7), 9D, 9E (nine E1, nine E2, nine E3), 9G, 9H -- Coil parts, 9F1, 9F2 [-- Precursive insulating layer,] -- Lead wire, 11H, 18H -- A connection hole, 11P 13 [-- Back end section,] -- A lower magnetic pole, 13A, 17A -- A point, 13B, 17B 14 [-- A pneumatic bearing side, 100 / -- A magnetic pole portion, I / -- Current, J / -- Magnetic flux, TH / -- Throat height, U1 (U1A, U1B U1C) / -- The 1st winding unit, U2 (U2A, U2B, U2C) / -- 2nd winding unit.] -- A record gap layer, 19 -- An overcoat layer, 20

[Translation done.]